

# NATIONAL BUREAU OF STANDARDS REPORT

6965

on  
Interlaboratory Intercomparisons  
of  
40-Watt T 12 Colored Fluorescent Lamps

by  
Velma I. Burns  
Photometry and Colorimetry Section  
Metrology Division



U. S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS

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# NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT

September 26, 1960

NBS REPORT

0201-20-02113

6965

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U. S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS



Interlaboratory Intercomparisons  
of  
40-Watt T 12 Colored Fluorescent Lamps

Abstract

Four groups of colored 40-watt T 12 fluorescent lamps were measured. Each group consists of six lamps of the same color; the colors are: pink, gold, blue, and green. Five laboratories made measurements of luminous flux, lamp current, lamp voltage, and lamp watts. The line voltage was held constant at 236 volts across the lamp in series with a reactor having an impedance of 439 ohms and a power factor of 7-8%. The luminous flux measurements were made at each laboratory in an integrating sphere photoelectrically and two laboratories made additional measurements by using a spectroradiometer. The results of the measurements made by the individual laboratories and an analysis of the results are given in this report.

I Introduction

This intercomparison was undertaken to determine the uniformity of measurements on 40-watt fluorescent lamps of pink, gold, blue, and green colors made at the participating laboratories. The laboratories participating and the order of reading the lamps are as follows:

- I.    Sylvania
- II.   Westinghouse
- III.  Interlectric
- IV.   Duro Test
- V.    General Electric

Each laboratory followed its own customary procedure in making the measurements. Measurements in each laboratory were obtained by holding the line voltage at 236 volts. A reference ballast adjusted to 439 ohms impedance and 7-8% power factor was used. The supply was connected to the marked pins. Each laboratory measured the luminous flux in an integrating sphere photoelectrically, and in addition two of the laboratories measured the lamps by means of a spectroradiometer.

II Results of Measurements

The results reported are given in tables 1 through 16. For each color the averages of the reported values for each lamp and for each laboratory are given. The difference between the average for each laboratory and the average of all laboratories for all lamps of each color is also given in the tables.



Table 1.

F4OT12 Pink  
Lumens

Lamp No.	Photoelectric Measurements						Spectro- radiometric Measurements	
	Syl.	West.	Interl	Duro T	G.E.	Ave.	Syl.	Duro T
1	943	1098	1097	1115	964	1043.4	971	991
2	1042	1199	1197	1223	1053	1142.8	1026	1017
3	915	1035	1023	1060	883	983.2	988	960
4	1112	1284	1292	1310	1153	1230.2	1161	1146
5	1141	1324	1327	1345	1179	1263.2	1239	1245
6	1097	1281	1282	1303	1123	1217.2	1172	1158
ave.	1041.7	1203.5	1203.0	1226.0	1059.2	1146.7	1093	1086
$\Delta$	-105.0	+ 56.8	+ 56.3	+ 79.3	- 87.5			
% $\Delta$	- 9.2%	+ 5.0%	+ 4.9%	+ 6.9%	- 7.6%			

Table 2.

F4OT12 Gold  
Lumens

Lamp No.	Photoelectric Measurements						Spectro- radiometric Measurements	
	Syl.	West.	Interl	Duro T	G.E.	Ave	Syl	Duro T
7	1720	1860	1807	1904	1786	1815.4	1628	1832
8	1746	1887	1847	1913	1789	1836.4	1660	1813
9	1698	1819	1782	1858	1754	1782.2	1622	1790
10	1710	1875	1828	1905	1774	1818.4	1597	2188
11	1702	1869	1830	1905	1779	1817.0	1630	1808
12	1702	1854	1835	1901	1774	1813.2	1656	1855
ave.	1713.0	1860.7	1821.5	1897.7	1776.0	1813.8	1632	1881
$\Delta$	- 100.8	+ 146.9	+ 7.7	+ 83.9	- 37.8			
% $\Delta$	- 5.6%	+ 2.6%	+ 0.4%	+ 4.6%	- 2.1%			

Table 3.

F4OT12 - Blue  
Lumens

Lamp No.	Photoelectric Measurements						Spectro- radiometric Measurements	
	Syl	West	Interl	Duro T	G.E.	Ave	Syl.	Duro T
13	1099	1038	1000	1010	1058	1041.0	963	1094
14	1081	1027	995	995	1056	1030.8	1153	1152
15	1091	1036					922	1141
16	1109	1056	1020	1023	1064	1054.4	1000	984
17	1117	1058	1025	1022	1073	1059.0	1060	1140
18	1101	1054	1017	1022	1063	1051.4	1029	1211
ave of 6	1100	1045					1021	1120
ave of 5	1101.4	1046.6	1011.4	1014.4	1062.8	1047.3	1041	1116
$\Delta$	+ 54.1	- 0.7	- 35.9	- 32.9	+ 15.5			
% $\Delta$	+ 5.2%	- 0.1%	- 3.4%	- 3.1%	+ 1.5%			

Table 4.

F4OT12-Green  
Lumens

Lamp No.	Photoelectric Measurements						Spectro- radiometric Measurements	
	Syl	West	Interl	Duro T	G.E.	Ave	Syl	Duro T
19	3568	3531	3422	3435	3463	3483.8		3464
20	3664	3595	3435	3506	3530	3546.0	3405	3804
21	3644	3592	3447	3465	3527	3535.0	3518	3610
22	3600	3487	3362	3380	3404	3446.6		3214
23	3544	3570	3392	3465	3496	3493.4		3654
24	3628	3569	3420	3446	3478	3508.2	3421	3514
ave	3608.0	3557.3	3413.0	3449.5	3483.0	3502.2		3543
$\Delta$	+ 105.8	+ 55.1	- 89.2	- 52.7	- 19.2			
% $\Delta$	+ 3.0%	+ 1.6%	- 2.5%	- 1.5%	- 0.5%			

Table 5.

F4OT12 - Pink  
Current

<u>Lamp</u> <u>No.</u>	<u>Syl</u>	<u>West</u>	<u>Interl</u>	<u>Duro T</u>	<u>GE</u>	<u>Ave</u>
1	.429	.433	.437	.429	.434	.4324
2	.426	.430	.435	.429	.434	.4308
3	.427	.431	.430	.427	.434	.4298
4	.428	.430	.430	.428	.433	.4298
5	.426	.430	.430	.428	.430	.4288
6	.429	.431	.430	.431	.434	.4310
ave	.4275	.4308	.4320	.4287	.4332	.4304
$\Delta$	-.0029	+.0004	+.0016	-.0017	+.0028	
% $\Delta$	-.67%	+.09%	+.37%	-.39%	+.65%	

Table 6.

F4OT12 - Gold  
Current

<u>Lamp</u> <u>No.</u>	<u>Syl</u>	<u>West.</u>	<u>Interl</u>	<u>Duro T</u>	<u>GE</u>	<u>Ave</u>
7	.429	.432	.434	.429	.433	.4314
8	.429	.431	.437	.431	.434	.4324
9	.430	.430	.431	.426	.432	.4298
10	.430	.432	.434	.430	.434	.4320
11	.432	.436	.438	.432	.436	.4348
12	.431	.431	.433	.430	.434	.4318
ave	.4302	.4320	.4345	.4297	.4338	.4320
$\Delta$	-.0018	.0000	+.0025	-.0023	+.0018	
% $\Delta$	-.42%	0%	+.58%	-.53%	+.42%	



Table 7.

F4OT12 - Blue  
Current

Lamp No.	Syl.	West	Interl	Duro T	GE	Ave
13	.427	.425	.430	.425	.430	.4274
14	.427	.430	.431	.428	.432	.4296
15	.421	.425				
16	.427	.429	.431	.428	.432	.4294
17	.423	.429	.430	.425	.429	.4272
18	.423	.428	.430	.425	.428	.4268
ave of 6	.425	.428				
ave of 5	.4254	.4282	.4304	.4262	.4302	.4281
$\Delta$	-.0027	+.0001	+.0023	-.0019	+.0021	
% $\Delta$	-.63%	+.02%	+.54%	-.44%	+.49%	

Table 8.

F4OT12 - Green  
Current

Lamp No.	Syl.	West.	Interl	Duro T	GE	Ave
19	.425	.429	.430	.428	.433	.4290
20	.426	.425	.430	.422	.433	.4272
21	.424	.427	.430	.422	.430	.4266
22	.425	.432	.431	.425	.435	.4296
23	.431	.429	.432	.426	.431	.4298
24	.424	.429	.430	.424	.431	.4276
ave	.4258	.4285	.4305	.4245	.4322	.4283
$\Delta$	-.0025	+.0002	+.0022	-.0038	+.0039	
% $\Delta$	-.58%	+.05%	+.51%	-.89%	+.91%	

Table 9.

F4OT12 - Pink  
Volts

Lamp No.	Syl.	West.	Interl	GE	Ave
1	100.5	100.6	99.4	100.5	100.25
2	102.0	100.9	99.6	100.2	100.68
3	100.5	100.9	100.4	99.5	100.32
4	100.5	102.0	101.5	99.8	100.95
5	101.5	102.0	100.9	102.0	101.60
6	100.0	100.9	100.8	100.5	100.55
ave	100.83	101.22	100.43	100.42	100.72
$\Delta$	+ .11	+ .50	- .29	- .30	
% $\Delta$	+ .11%	+ .50%	- .29%	- .30%	

Table 10.

F4OT12 - Gold  
Volts

Lamp No.	Syl.	West.	Interl	GE	Ave
7	100.0	100.0	98.9	101.0	99.98
8	99.0	99.8	97.3	99.8	98.98
9	99.5	101.5	100.8	100.6	100.60
10	98.5	100.0	98.8	99.9	99.30
11	98.5	98.1	97.7	99.5	98.45
12	97.5	100.3	100.1	100.1	99.50
ave	98.83	99.95	98.93	100.15	99.47
$\Delta$	- .64	+ .48	- .54	+ .68	
% $\Delta$	- .64%	+ .48%	- .54%	+ .68%	

Table 11.

F4OT12 - Blue  
Volts

<u>Lamp No.</u>	<u>Syl.</u>	<u>West</u>	<u>Interl</u>	<u>GE</u>	<u>Ave</u>
13	101.0	104.0	101.0	100.8	101.70
14	100.5	102.4	100.8	100.3	101.00
15	103.0	104.9			
16	100.0	103.1	100.6	100.3	101.00
17	102.0	102.9	101.4	102.0	102.08
18	101.0	102.8	101.9	102.6	102.08
ave of 6	101.2	103.4			
ave of 5	100.90	103.04	101.14	101.20	101.57
$\Delta$	- .67	+ 1.47	- .43	- .37	
% $\Delta$	- .66%	+ 1.45%	- .42%	- .36%	

Table 12.

F4OT12 - Green  
Volts

<u>Lamp No.</u>	<u>Syl.</u>	<u>West.</u>	<u>Interl</u>	<u>Duro T</u>	<u>GE</u>	<u>Ave</u>
19	101.0	102.6	101.8		100.9	101.58
20	101.5	104.3	102.4		100.0	102.05
21	103.0	104.0	102.7		101.7	102.85
22	101.5	101.6	100.3		99.4	100.70
23	99.0	101.8	100.8		101.9	100.88
24	102.0	103.5	102.7		101.2	102.35
ave	101.33	102.97	101.78		100.85	101.73
$\Delta$	- .40	+ 1.24	+ .05		- .88	
% $\Delta$	- .39%	+ 1.22%	+ .05%		- .87%	

Table 13.

F4OT12 - Pink  
Watts

<u>Lamp No.</u>	<u>Syl.</u>	<u>West</u>	<u>Interl</u>	<u>Duro T</u>	<u>GE</u>	<u>Ave</u>
1	39.1	39.5		39.2	40.0	39.45
2	40.0	39.3		39.1	40.1	39.62
3	39.4	39.2		39.1	39.7	39.35
4	39.2	39.8		39.0	39.4	39.35
5	39.6	39.9		39.3	40.4	39.80
6	39.2	39.2		39.0	39.9	39.32
ave	39.42	39.48		39.12	39.92	39.48
$\Delta$	- .06	.00		- .36	+ .44	
% $\Delta$	- .15%	0%		- .91%	+ 1.1%	

Table 14.

F4OT12 - Gold  
Watts

<u>Lamp No.</u>	<u>Syl.</u>	<u>West</u>	<u>Interl</u>	<u>Duro T</u>	<u>GE</u>	<u>Ave</u>
7	39.3	39.0		39.2	39.9	39.35
8	38.9	38.9		38.6	39.8	39.05
9	39.1	39.4		39.6	39.9	39.50
10	38.8	38.9		38.8	39.8	39.08
11	39.1	38.4		38.7	39.7	38.98
12	38.4	39.0		38.7	39.7	38.95
ave	38.93	38.93		38.93	39.80	39.15
$\Delta$	- .22	- .22		- .22	+ .65	
% $\Delta$	- .56%	- .56%		- .56%	+ 1.66%	

Table 15.

F4OT12 - Blue  
Watts

<u>Lamp No.</u>	<u>Syl.</u>	<u>West</u>	<u>Interl</u>	<u>Duro T</u>	<u>GE</u>	<u>Ave</u>
13	39.5	40.2		39.3	39.7	39.68
14	39.3	39.8		39.2	39.5	39.45
15	39.7	40.2				
16	39.2	40.0		39.1	39.5	39.45
17	39.5	39.7		39.4	40.0	39.65
18	39.1	39.4		39.4	40.0	39.48
ave 6	39.4	39.9				
ave of 5	39.32	39.82		39.28	39.74	39.54
$\Delta$	- .22	+ .28		- .26	+ .20	
% $\Delta$	- .56%	+ .71%		- .66%	+ .51%	

Table 16.

F4OT12 - Green  
Watts

<u>Lamp No.</u>	<u>Syl.</u>	<u>West</u>	<u>Interl</u>	<u>Duro T</u>	<u>GE</u>	<u>Ave</u>
19	39.3	39.8		39.7	40.1	39.72
20	39.8	40.3		40.4	39.7	40.05
21	40.0	40.0		40.3	40.1	40.10
22	39.7	39.4		40.2	39.6	39.72
23	39.1	39.5		40.0	40.3	39.72
24	39.6	40.1		40.4	40.1	40.05
ave	39.58	39.85		40.17	39.98	39.89
$\Delta$	- .31	- .04		+ .28	+ .09	
% $\Delta$	- .78%	- .10%		+ .70%	+ .23%	



### III Analysis of the Results

An analysis of the results of the measurements has been made following a modification of the method described by W. J. Youden 1, 2, 3. This modified method is described in National Bureau of Standards Report No.6605 "Interlaboratory Intercomparisons of 32-Watt T10 Cool-White Circline Lamps" and No.6698 "Interlaboratory Intercomparisons of 40-Watt T12 Cool-White Fluorescent Lamps". The analysis is shown on the following graphs. The point representing measurements by each individual laboratory is designated by the first letter in the name of the laboratory. The point representing the average of all laboratories is designated by the letter A.

1. Graphical Diagnosis of Interlaboratory Test Results, Industrial Quality Control Vol. XV No. 11, May 1959.
2. Product Specifications and Test Procedures, Industrial and Engineering Chemistry, Vol. 50, page 914, October 1958.
3. Circumstances alter the cases, Industrial and Engineering Chemistry, Vol. 50, page 77A, December 1958.

Figure 1

Lumens

F40T12 Pink

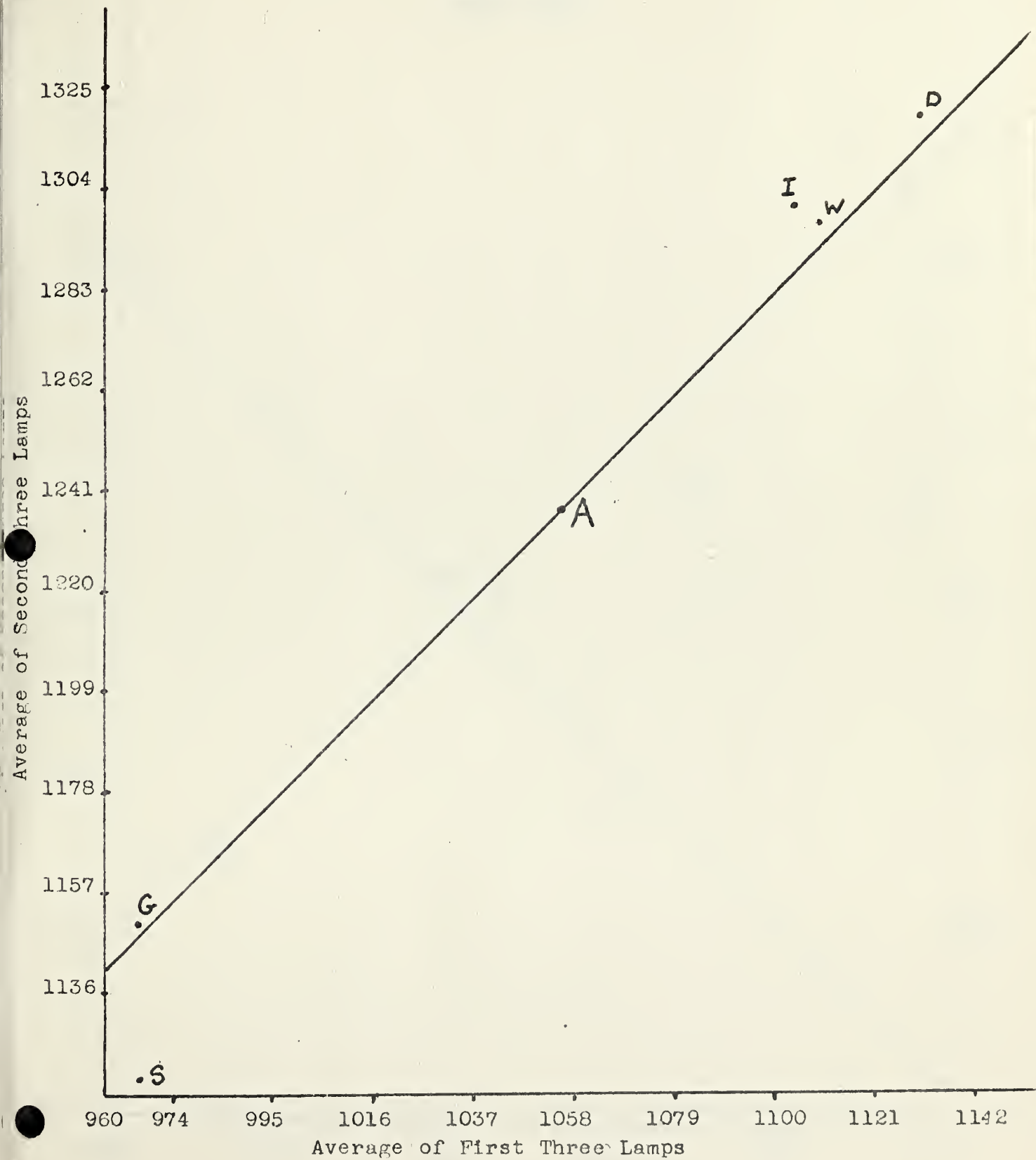


Figure 2

Lumens

F40T12 Gold

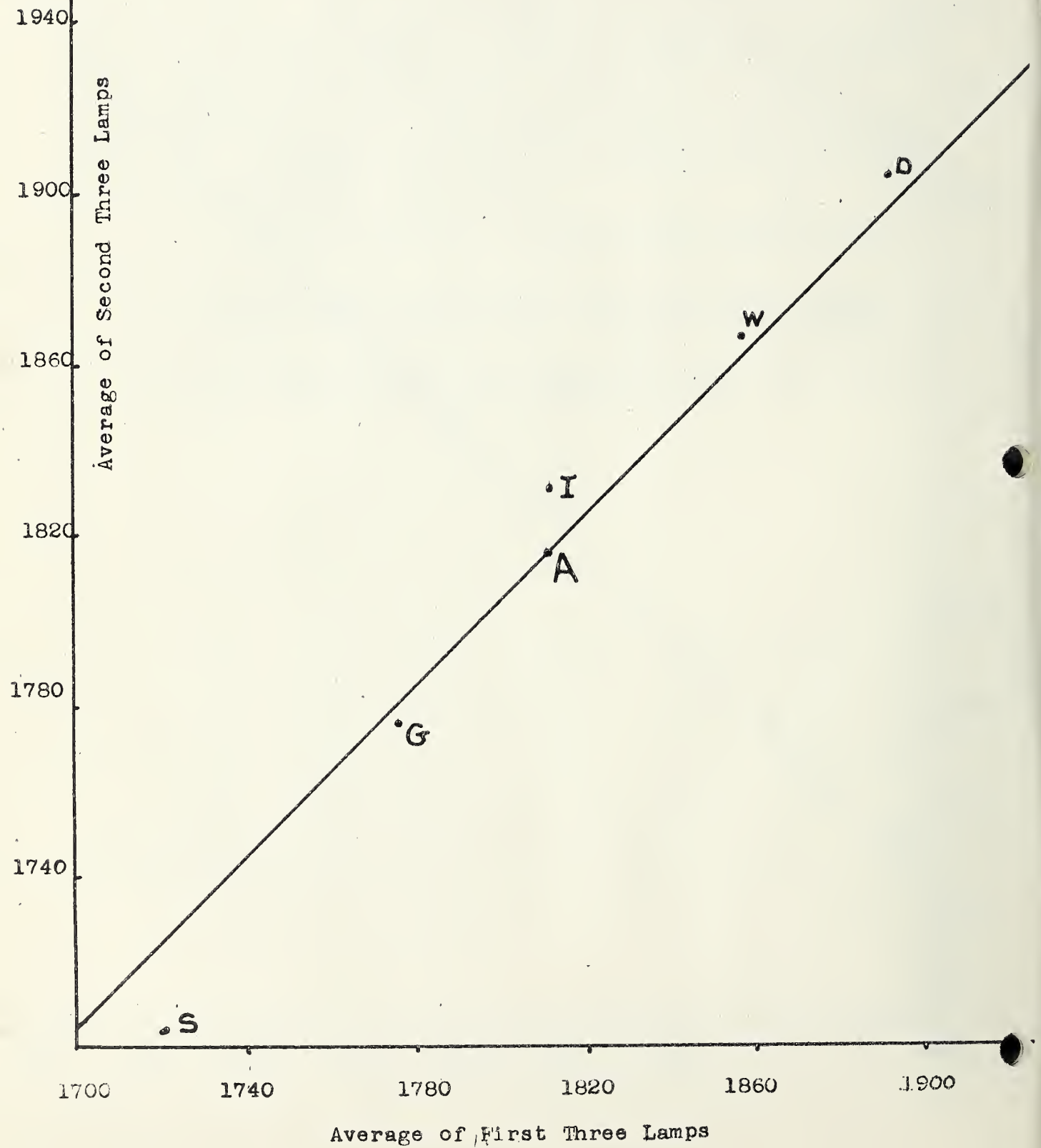


Figure 3

Lumens

F40T12 Blue

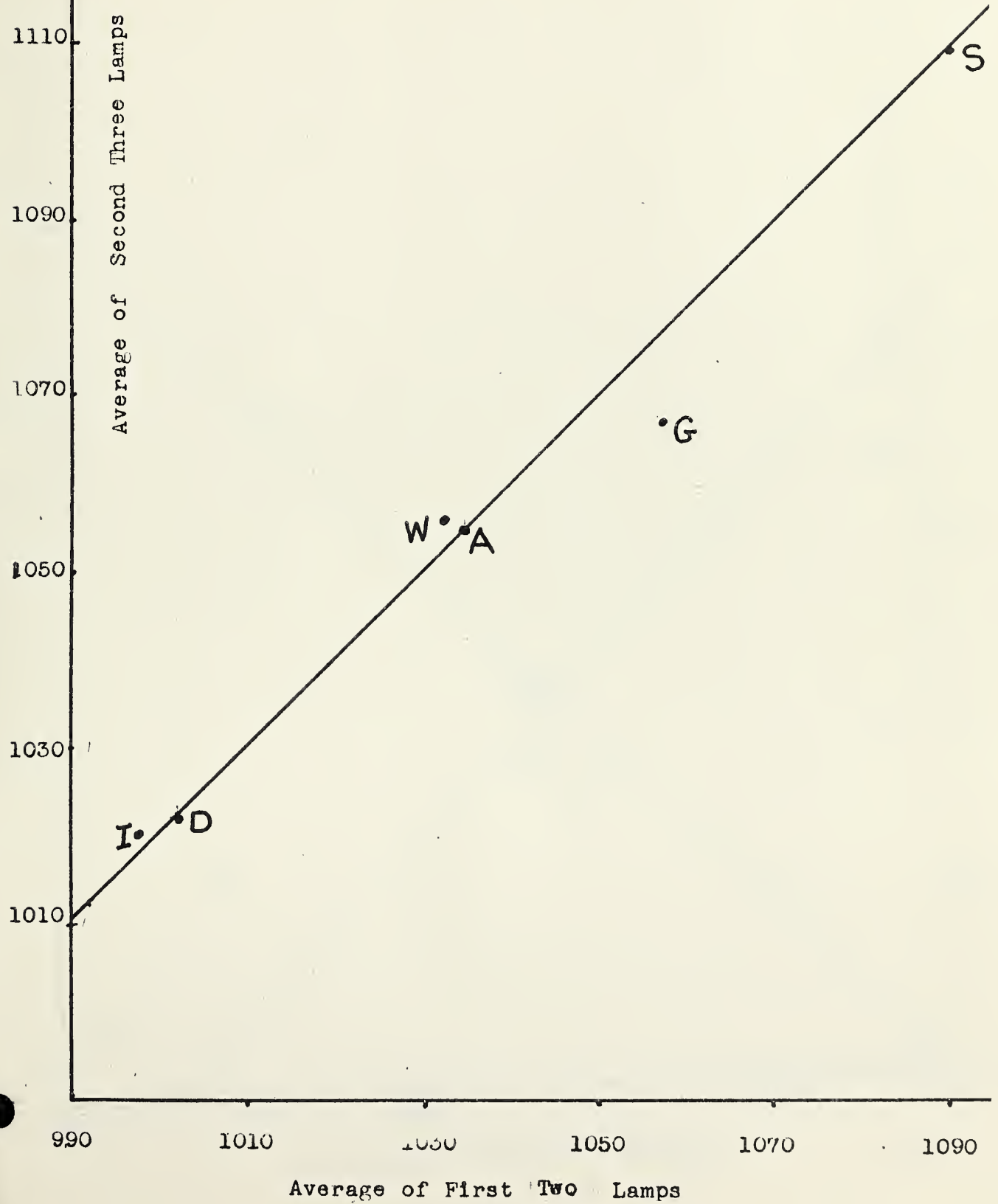


Figure 4

Lumens  
F40T12 Green

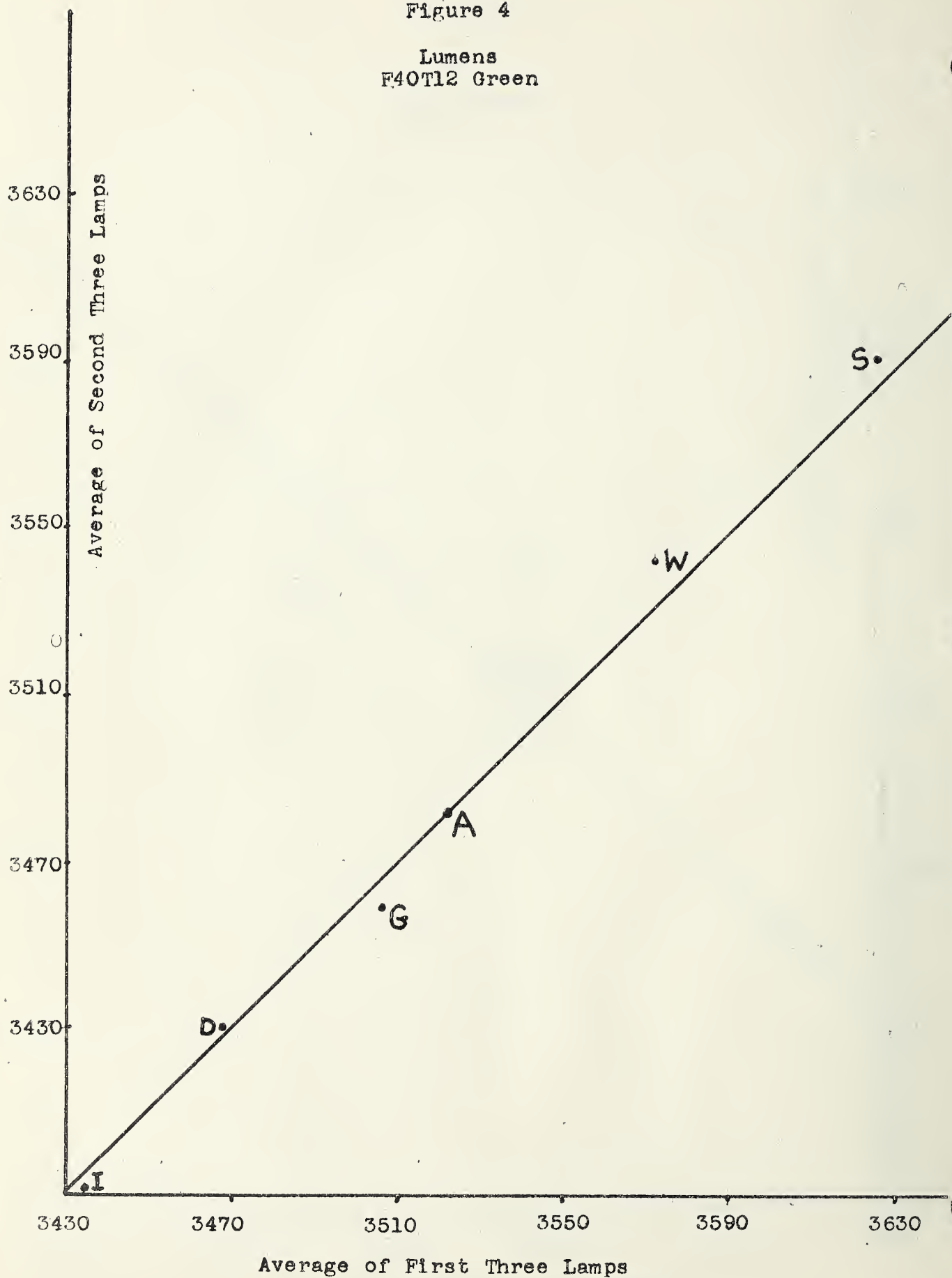




Figure 5  
Amperes  
F40T12 Pink

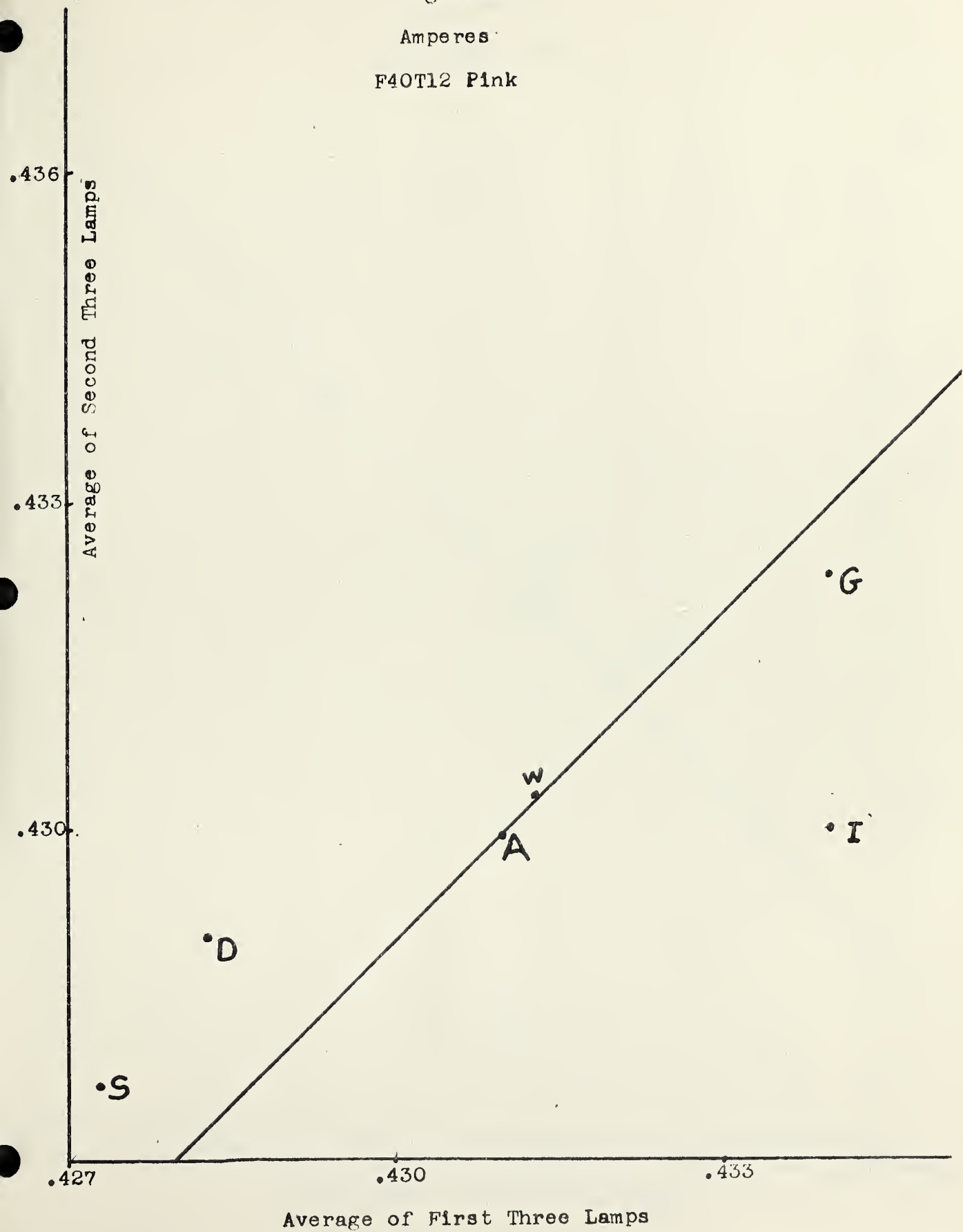


Figure 6

Amperes

F40T12 Gold

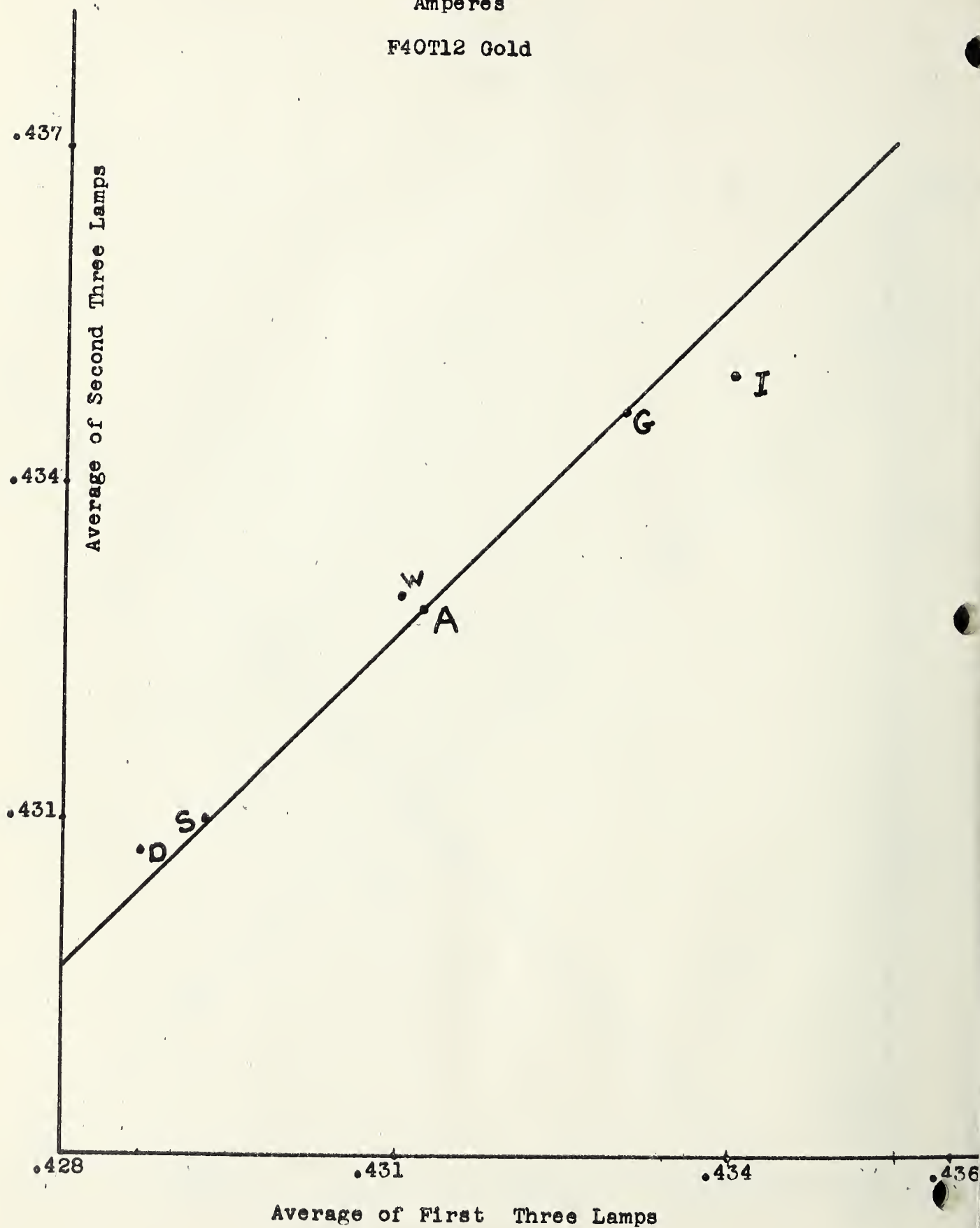


Figure 7.  
Amperes  
F40T12 Blue

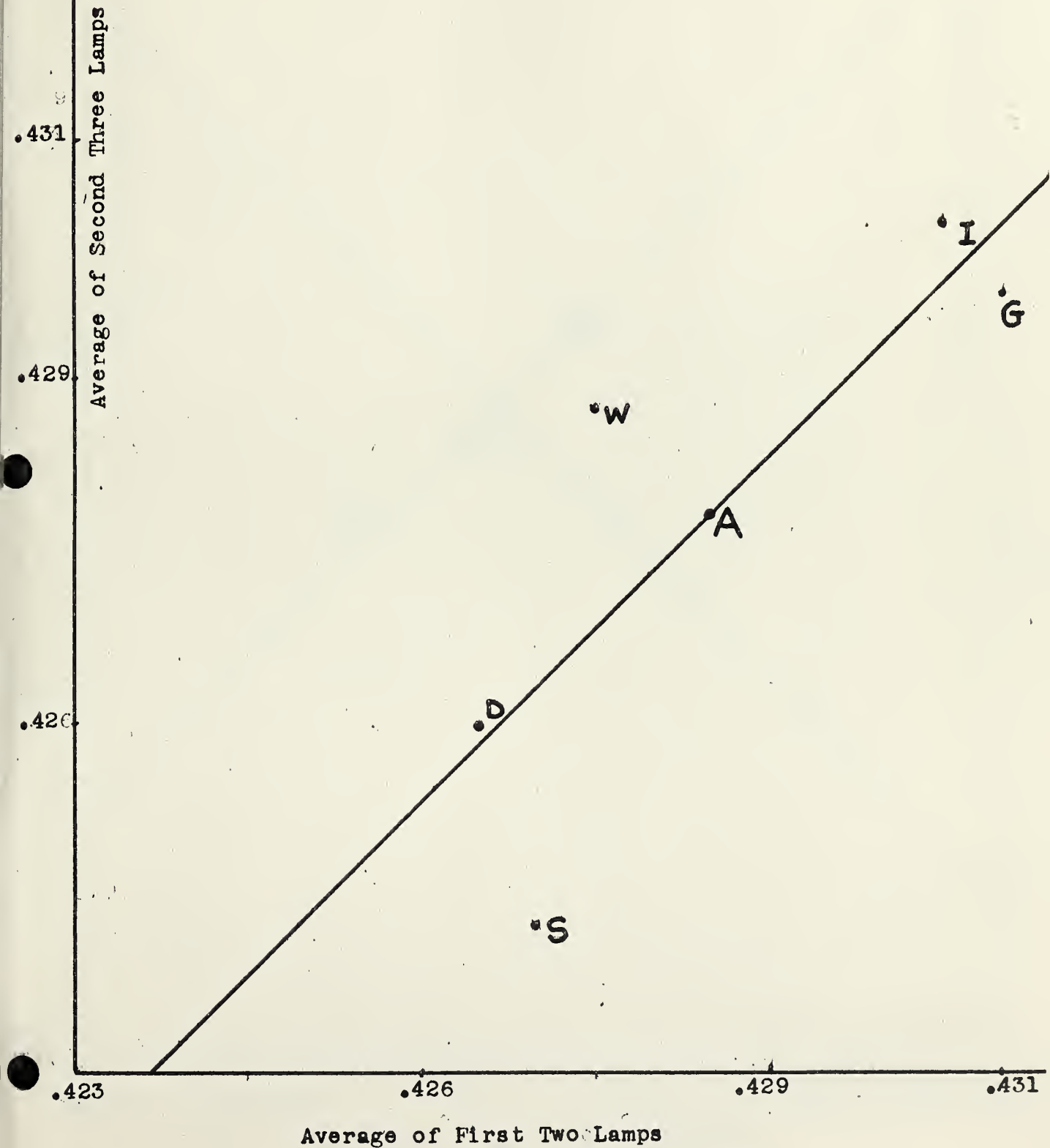


Figure 8

Amperes

F40T12 Green

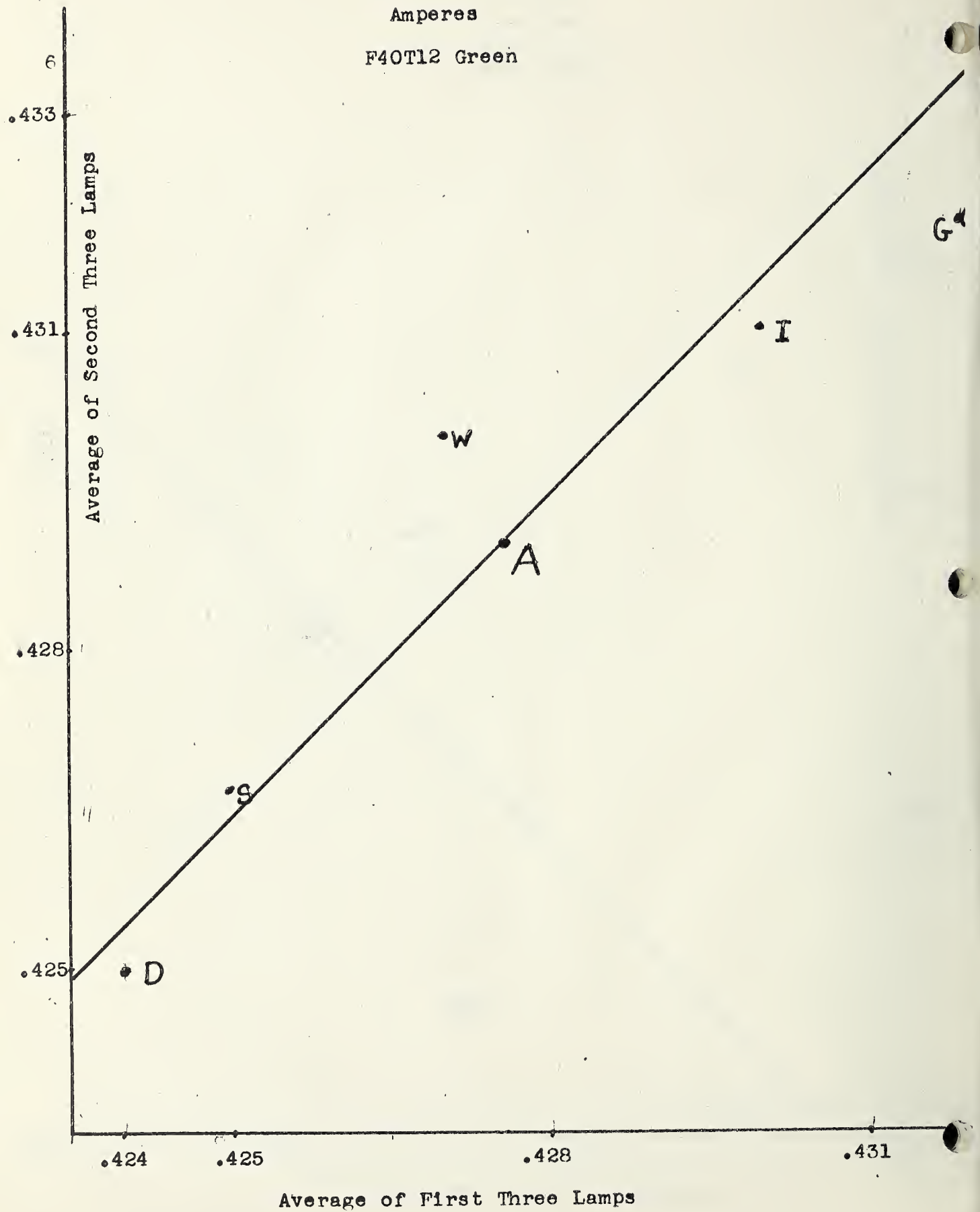


Figure 9  
Volts  
F40T12 Pink

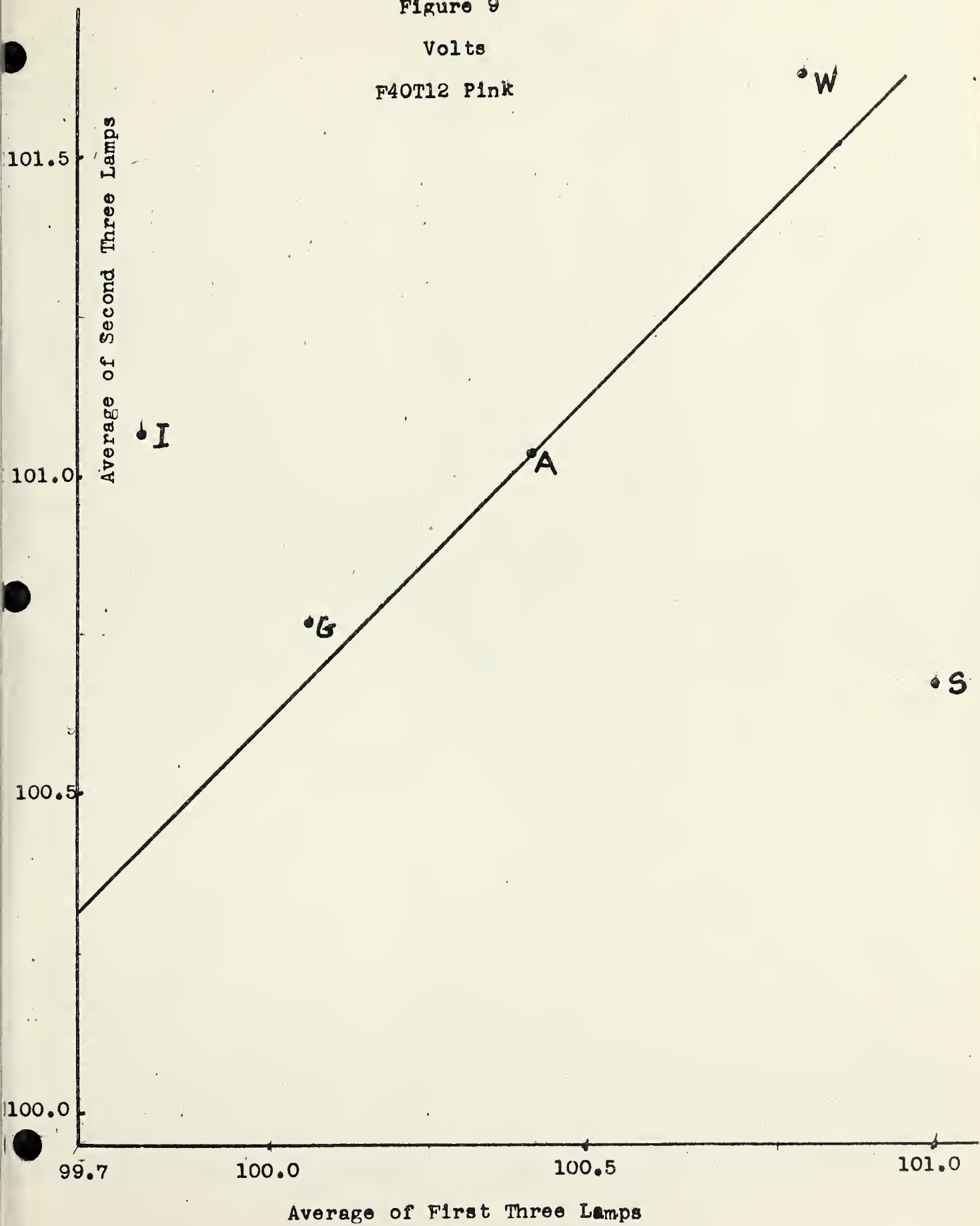




Figure 10  
Volts  
F40T12 Gold

Average of Second Three Lamps

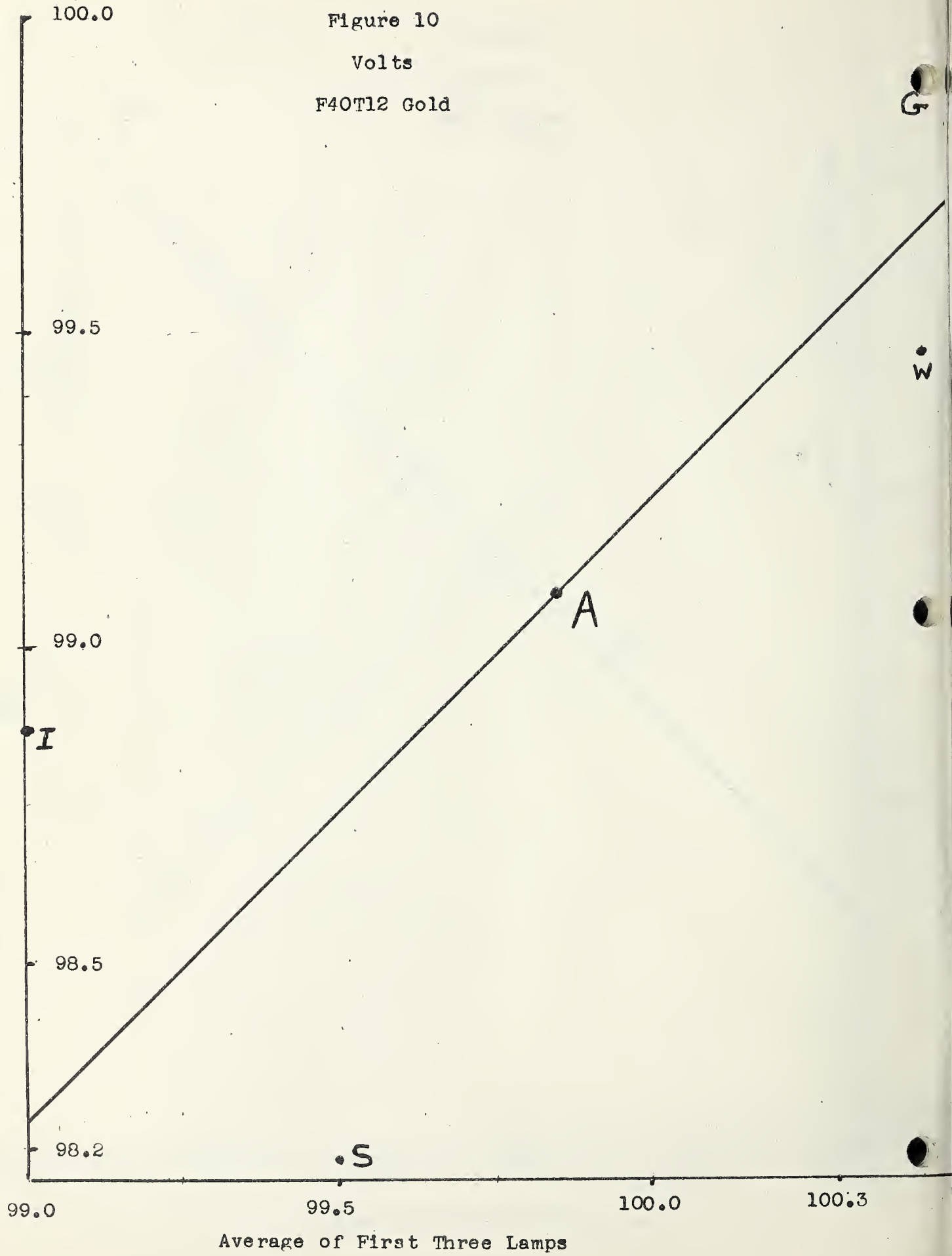


Figure 11

Volts

F40T12 Blue

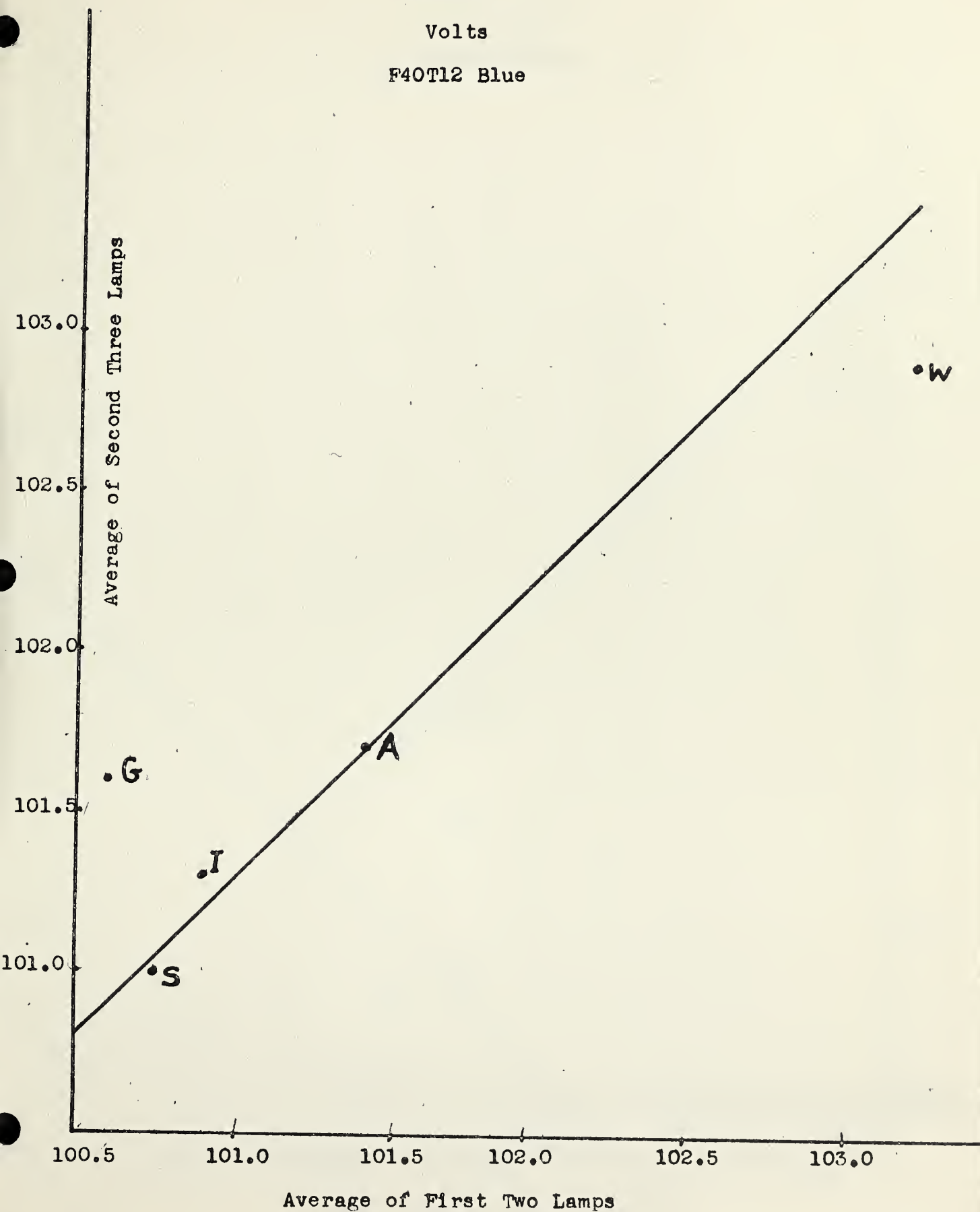


Figure 12  
Volts  
F40T12 Green

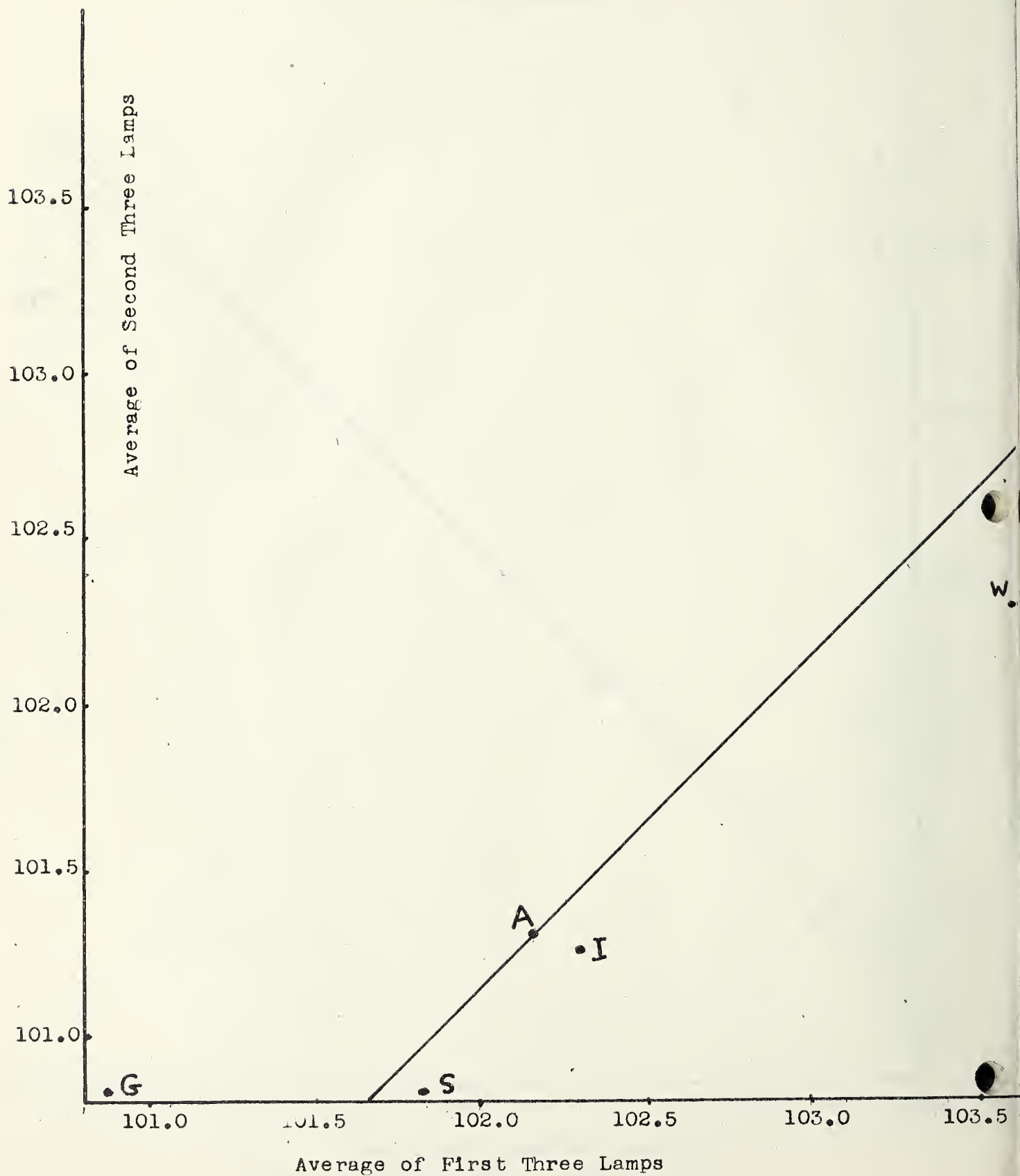


Figure 13

Watts

F40T12 Pink

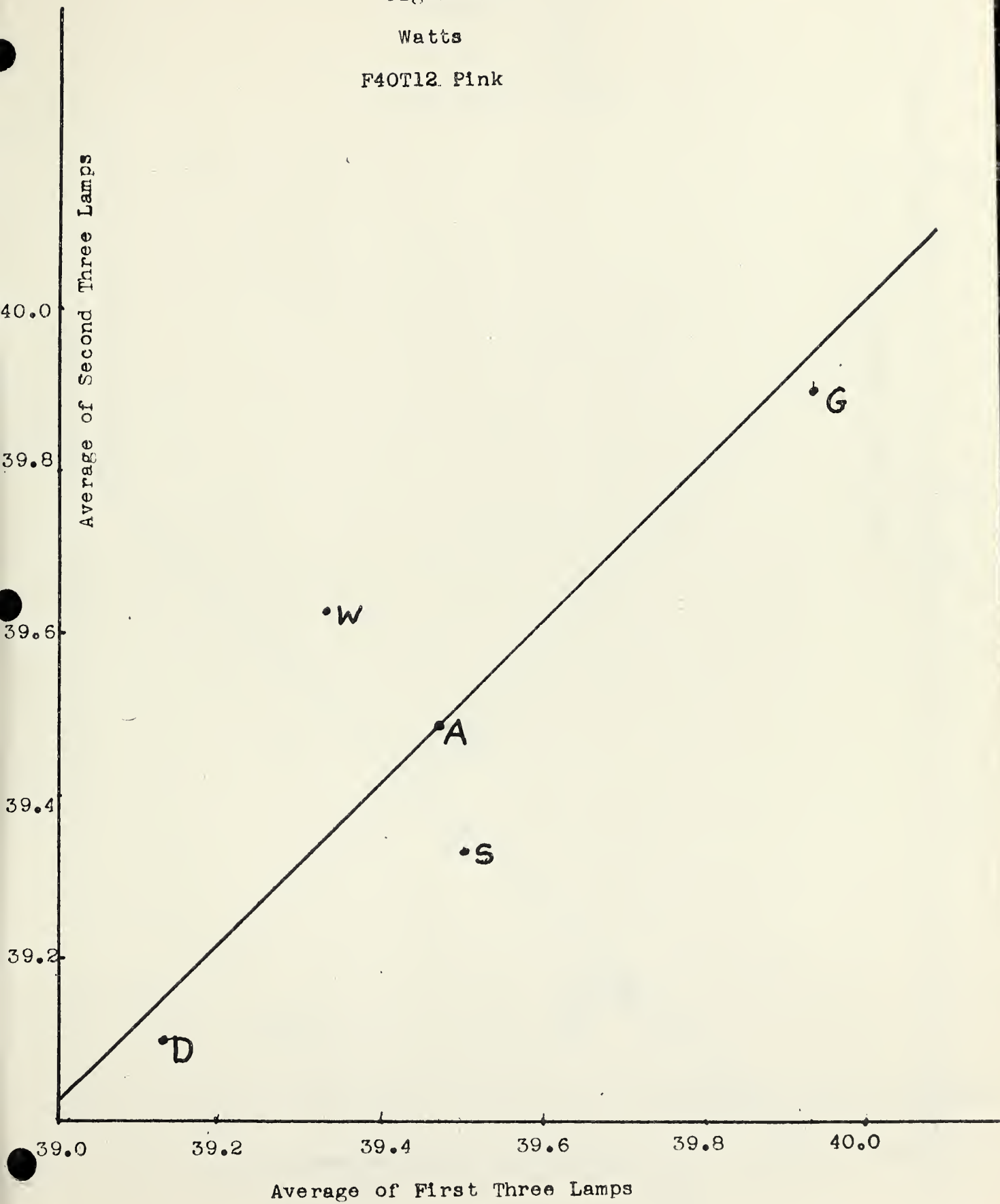


Figure 14

Watts

F40T12 Gold

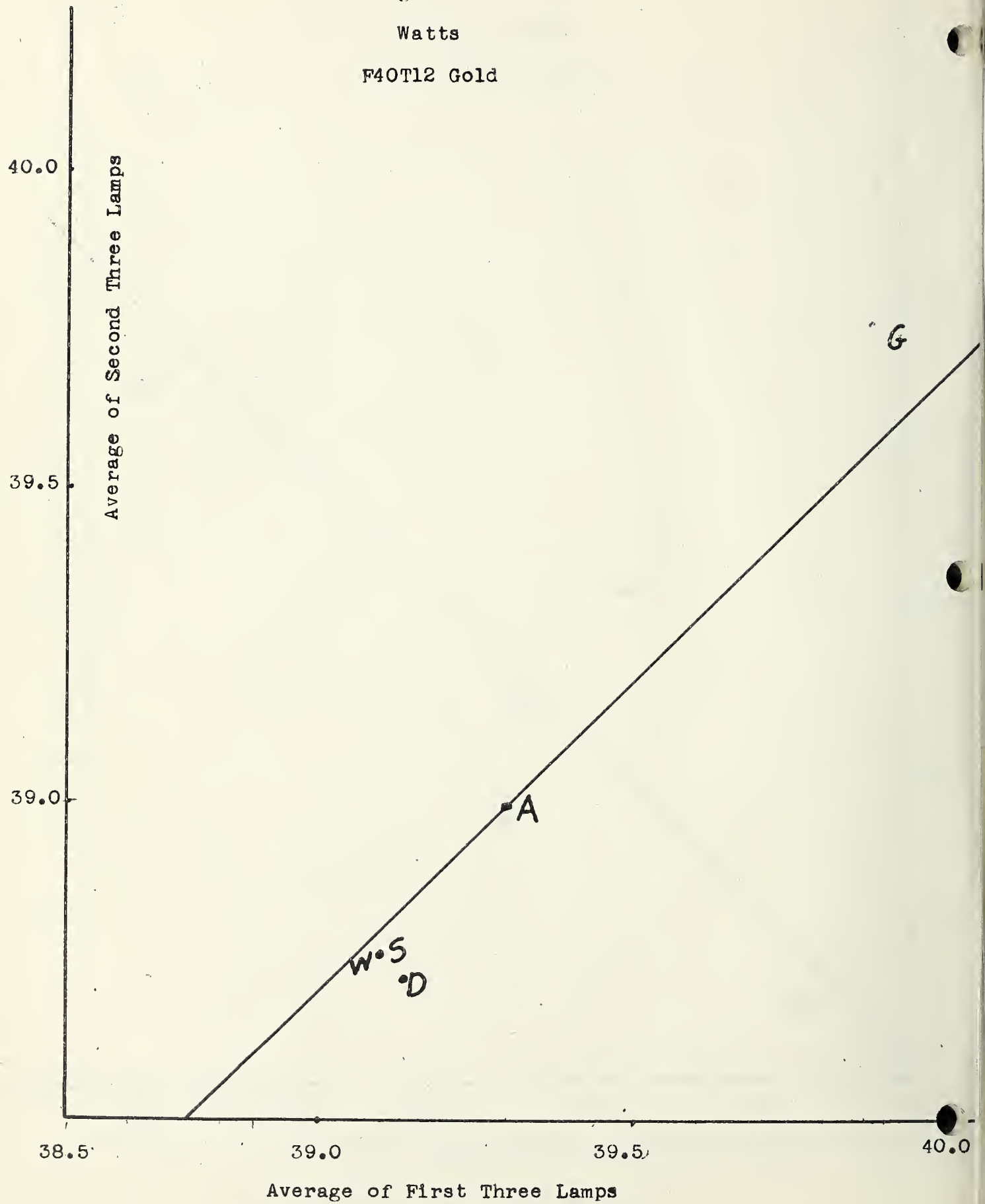




Figure 15

Watts

F40T12 Blue

Average of Second Three Lamps

40.1

39.8

39.5

39.2

39.5

39.8

40.0

Average of First Two Lamps

D

S

A

W

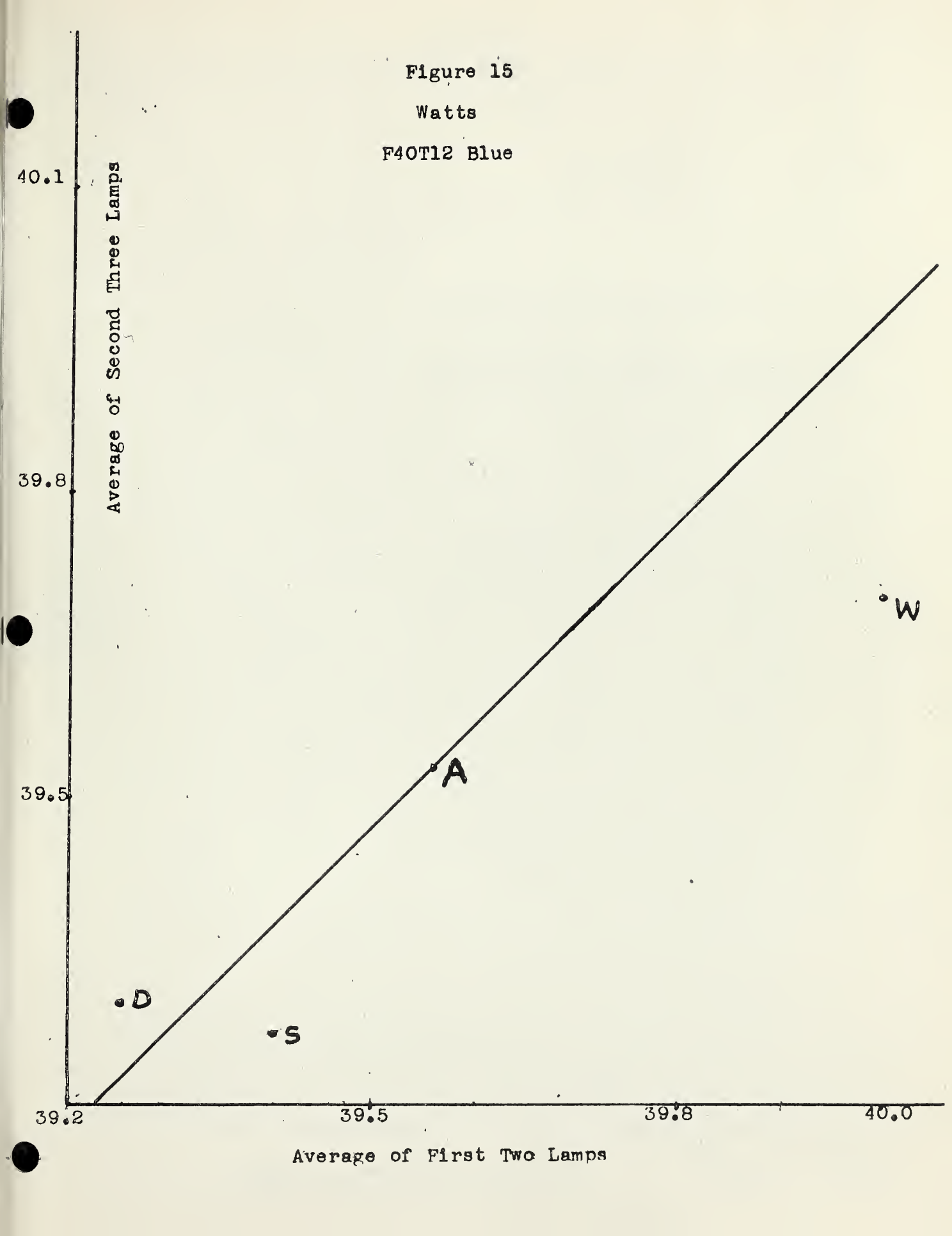


Figure 16

Watts

F40T12 Green

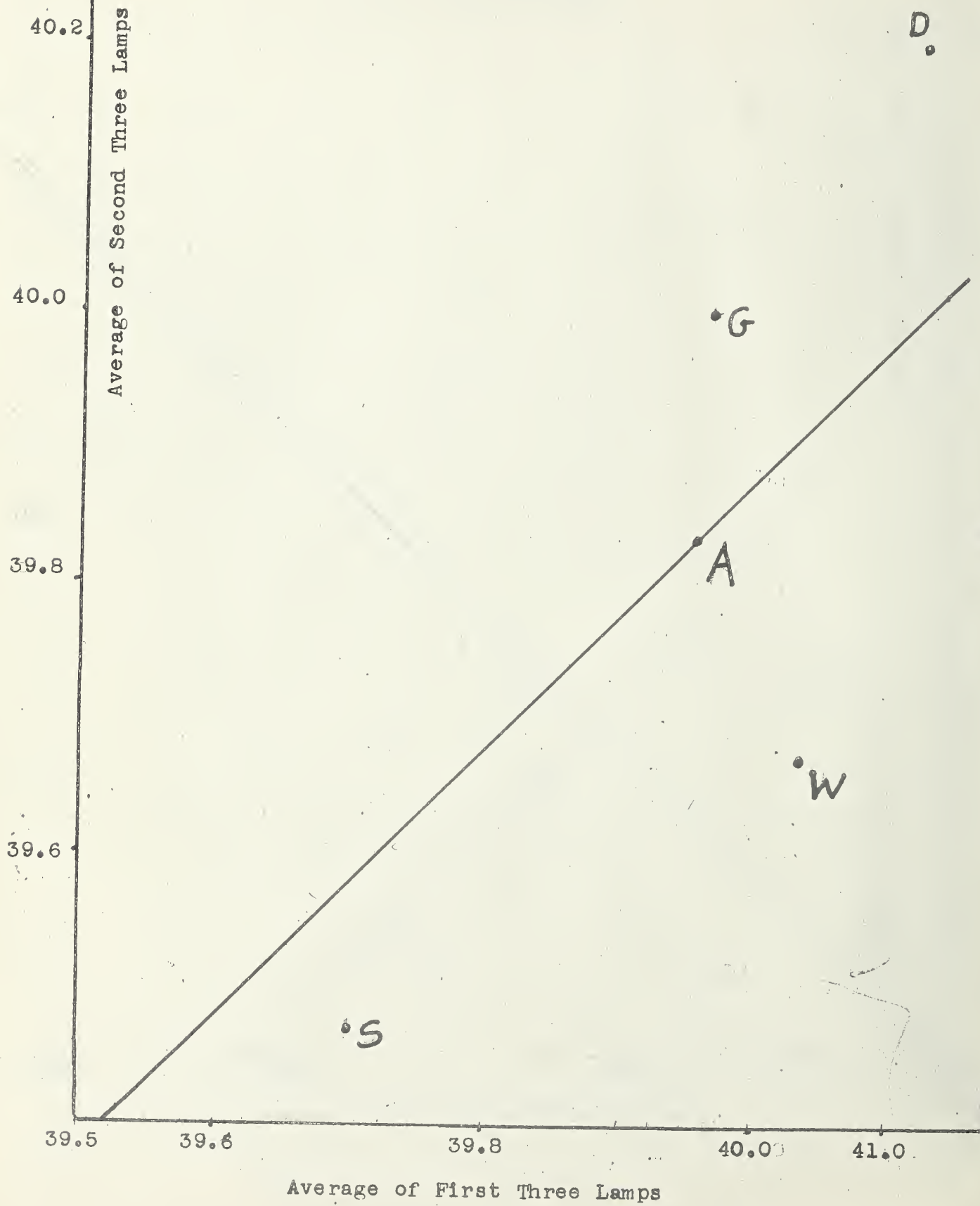




Figure 17

LUMENS  
R40T12 PLIK

Range of Individual Readings

100

200

300

% Difference from all Laboratories Average

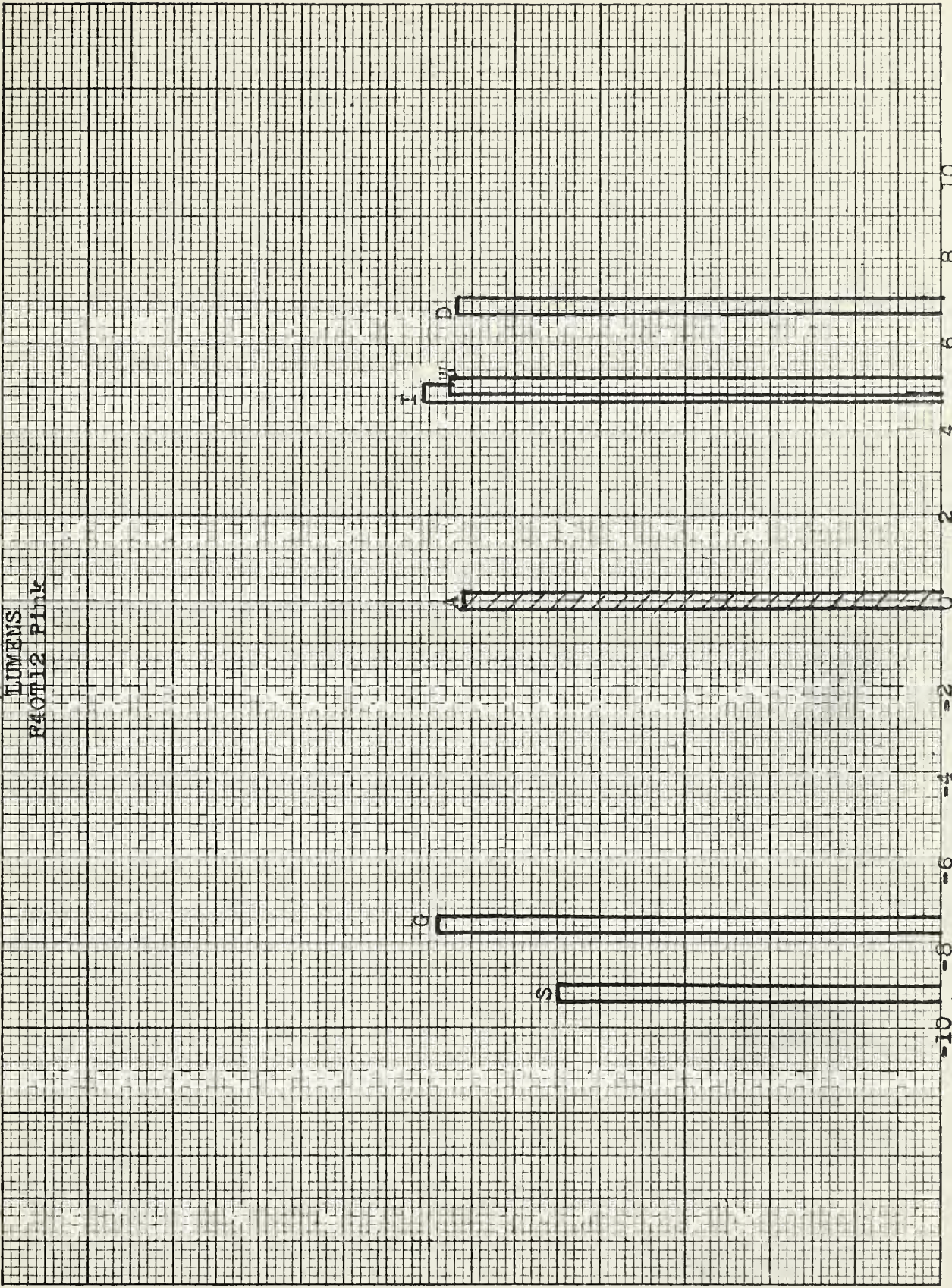
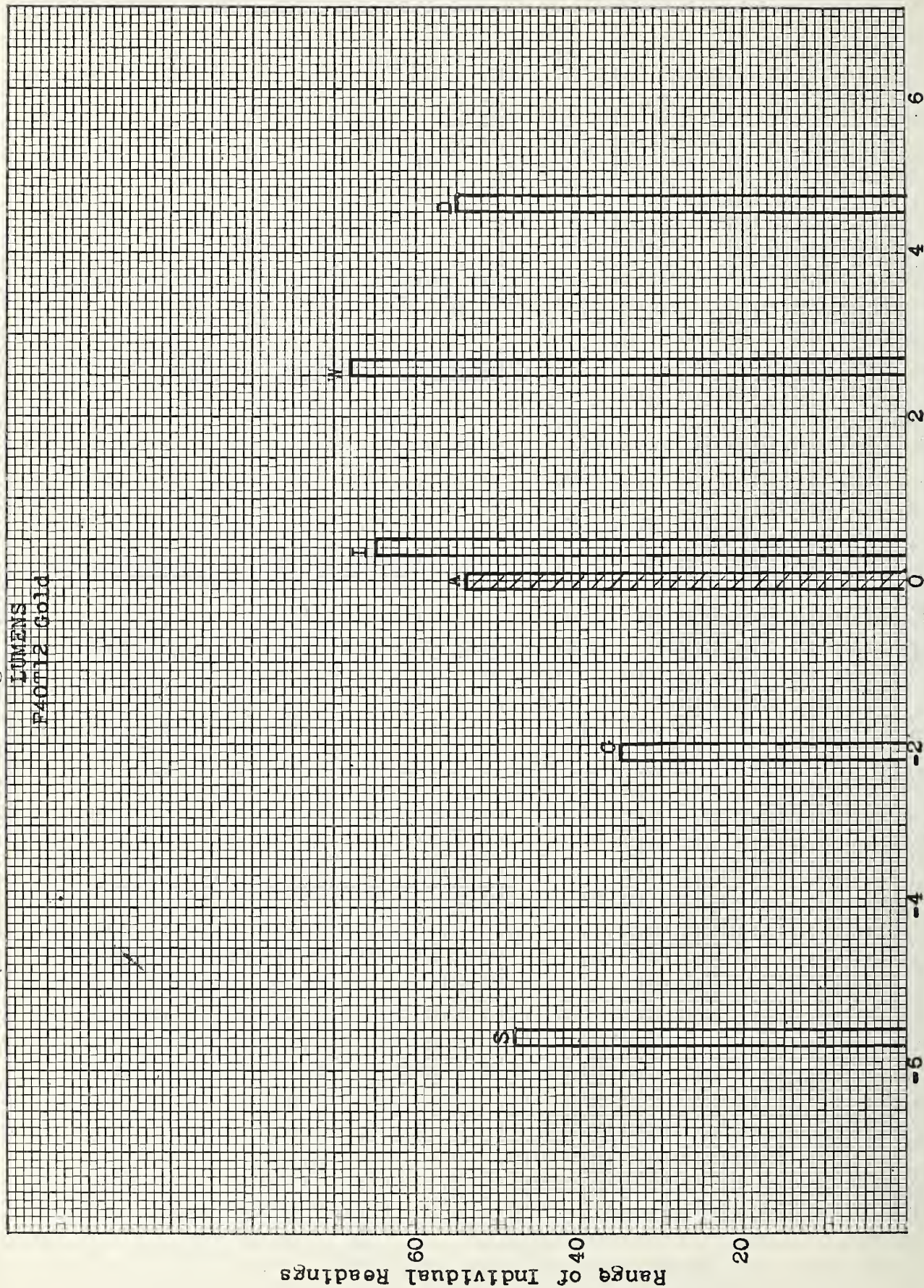




Figure 18



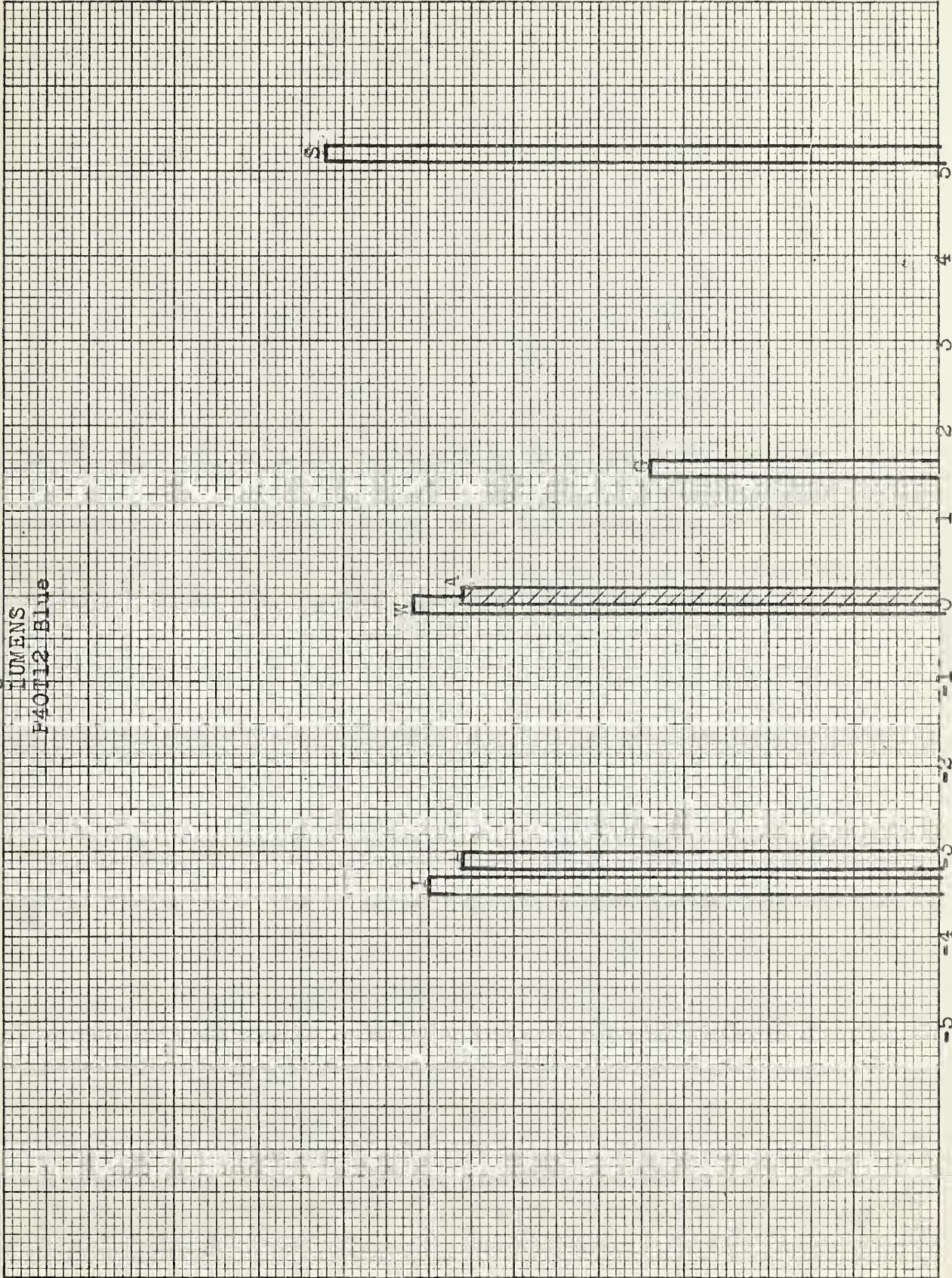
% Difference from all Laboratories Average



Figure 19

LUMENS  
P40T12 Blue

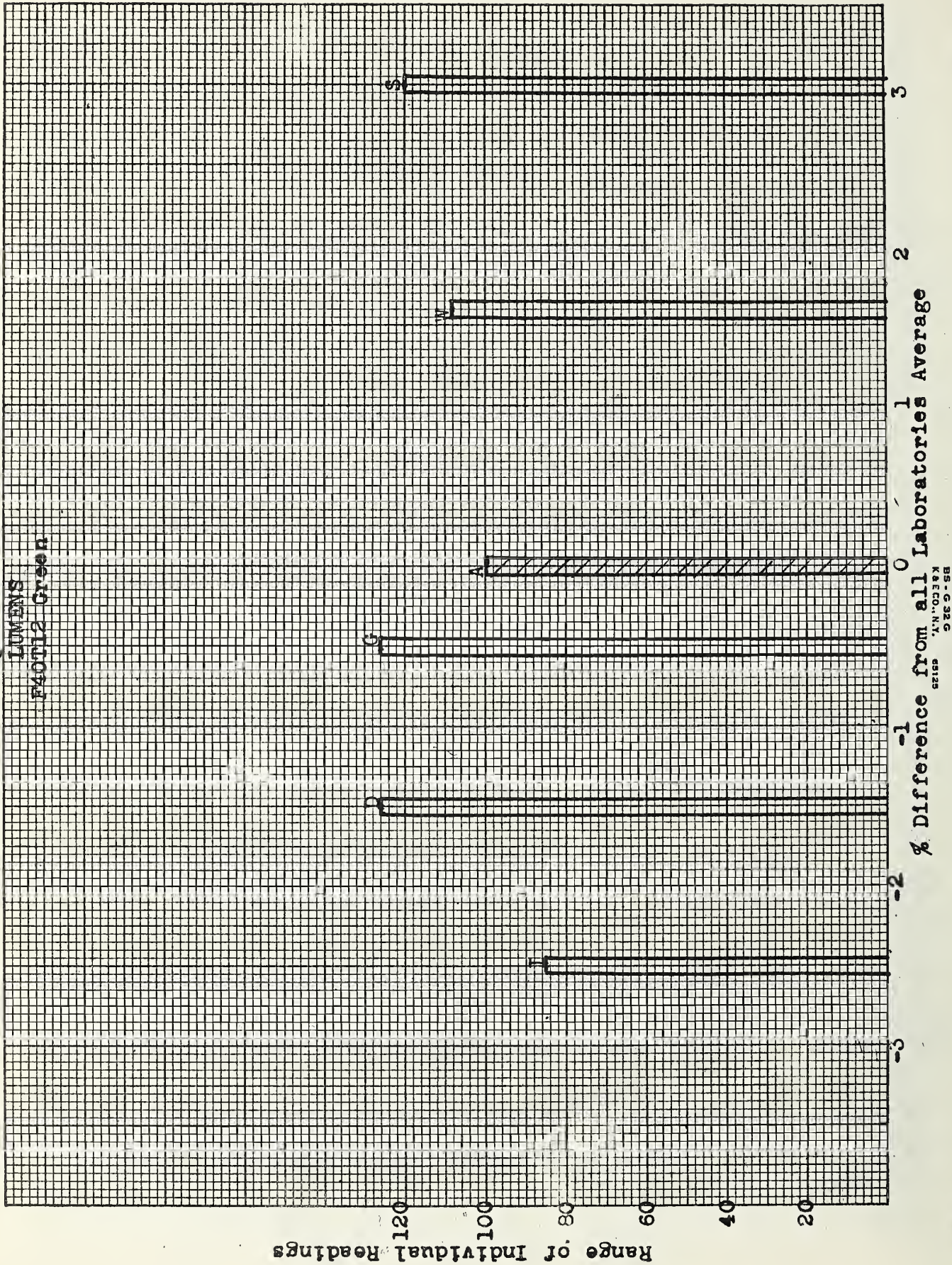
Range of Individual Readings



% Difference from all Laboratories Average



Figure 20





U.S. DEPARTMENT OF COMMERCE

Frederick H. Mueller, *Secretary*

NATIONAL BUREAU OF STANDARDS

A. V. Astin, *Director*



## THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colo., is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

### WASHINGTON, D.C.

**ELECTRICITY.** Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics.

**METROLOGY.** Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

**HEAT.** Temperature Physics. Heat Measurements. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research. Equation of State. Statistical Physics. Molecular Spectroscopy.

**RADIATION PHYSICS.** X-Ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

**CHEMISTRY.** Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

**MECHANICS.** Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Combustion Controls.

**ORGANIC AND FIBROUS MATERIALS.** Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

**METALLURGY.** Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

**MINERAL PRODUCTS.** Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

**BUILDING RESEARCH.** Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials.

**APPLIED MATHEMATICS.** Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

**DATA PROCESSING SYSTEMS.** Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Applications Engineering.

**ATOMIC PHYSICS.** Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics.

**INSTRUMENTATION.** Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Office of Weights and Measures.

### BOULDER, COLO.

**CRYOGENIC ENGINEERING.** Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

**IONOSPHERE RESEARCH AND PROPAGATION.** Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services.

**RADIO PROPAGATION ENGINEERING.** Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

**RADIO STANDARDS.** High frequency Electrical Standards. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time Standards. Electronic Calibration Center. Millimeter-Wave Research. Microwave Circuit Standards.

**RADIO SYSTEMS.** High Frequency and Very High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Space Telecommunications.

**UPPER ATMOSPHERE AND SPACE PHYSICS.** Upper Atmosphere and Plasma Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

